U.S. DEPARTMENT OF ENERGY

Advanced Research Projects Agency-Energy Annual Report for FY 2018

Report to Congress
September 2019

United States Department of Energy
Washington, DC 20585

arpa·e
CHANGING WHAT'S POSSIBLE

Message from the Director

The Advanced Research Projects Agency-Energy (ARPA-E) maintains a dynamic funding portfolio in which roughly one third of programs turn over annually. ARPA-E supports project teams whose technologies advance the boundaries of science and provides them with the strategic guidance necessary to effectively prepare for the deployment of their technologies.

In Fiscal Year 2018, we continued developing our diverse portfolio of advanced energy technologies. We issued five funding opportunity announcements (FOAs) including one to develop technologies that could enable designs for lower cost and safer advanced nuclear reactors (MEITNER) and another to build technologies to enable long-duration energy storage on the power grid (DAYS). Moreover, we announced projects ranging from developing a new class of sensor systems to enable significant energy savings via reduced demand for heating and cooling in buildings (SENSOR) to developing advanced natural gas fueled, distributed electric generation systems with conversion efficiencies of more than 70 percent (INTEGRATE).

This report is being provided to the following Members of Congress:

- **The Honorable Lisa Murkowski**
  Chairman, Senate Committee on Energy and Natural Resources
- **The Honorable Joe Manchin III**
  Ranking Member, Senate Committee on Energy and Natural Resources
- **The Honorable Bill Cassidy**
  Chairman, Senate Subcommittee on Energy
  Committee on Energy and Natural Resources
- **The Honorable Martin Heinrich**
  Ranking Member, Senate Subcommittee on Energy
  Committee on Energy and Natural Resources
- **The Honorable Frank Pallone, Jr.**
  Chairman, House Committee on Energy and Commerce
- **The Honorable Greg Walden**
  Ranking Member, House Committee on Energy and Commerce
- **The Honorable Eddie Bernice Johnson**
  Chairwoman, House Committee on Science, Space, and Technology
- **The Honorable Frank Lucas**
  Ranking Member, House Committee on Science, Space, and Technology

- **The Honorable Conor Lamb**
  Chairman, House Subcommittee on Energy
  Committee on Science, Space, and Technology

- **The Honorable Randy Weber**
  Ranking Member, House Subcommittee on Energy
  Committee on Science, Space, and Technology

- **The Honorable Richard Shelby**
  Chairman, Senate Committee on Appropriations

- **The Honorable Patrick Leahy**
  Vice Chairman, Senate Committee on Appropriations

- **The Honorable Lamar Alexander**
  Chairman, Senate Subcommittee on Energy and Water Development
  Committee on Appropriations

- **The Honorable Dianne Feinstein**
  Ranking Member, Senate Subcommittee on Energy and Water Development
  Committee on Appropriations

- **The Honorable Nita Lowey**
  Chairwoman, House Committee on Appropriations

- **The Honorable Kay Granger**
  Ranking Member, House Committee on Appropriations

- **The Honorable Marcy Kaptur**
  Chairwoman, House Subcommittee on Energy and Water Development
  Committee on Appropriations

- **The Honorable Mike Simpson**
  Ranking Member, House Subcommittee on Energy and Water Development
  Committee on Appropriations

If you have any questions or need additional information, please contact me or Ms. Jasmin Everett, Congressional Liaison, Office of the Chief Financial Officer, at (202) 586-2499, or Mr. Christopher Morris, Deputy Assistant Secretary for House Affairs or Mr. Shawn Affolter, Deputy Assistant Secretary for Senate Affairs, Office of Congressional and Intergovernmental Affairs, at 202-586-5450.

Sincerely,

Mr. Lane Genatowski
Director
Advanced Research Projects Agency-Energy

Executive Summary

The Advanced Research Projects Agency-Energy (ARPA-E) funds technologies that have the potential to change the way to get, store, and use energy. ARPA-E's mission is to advance energy innovations that will create a more secure, affordable, and sustainable American energy future.

ARPA-E focuses on early-stage energy technologies that can be meaningfully advanced with modest funding over a defined period of time. ARPA-E's rigorous program design, competitive project selection process, and hands-on engagement provide America's energy researchers with funding, technical assistance, and market awareness. Each year, ARPA-E thoroughly reviews all applications and technologies to ensure that funding is provided to areas not likely to be undertaken by industry, Federal agencies, or other DOE applied research and development.

This report presents a summary of the activities of ARPA-E during Fiscal Year (FY) 2018. In FY 2018[1], ARPA-E selected projects for four programs covering a broad array of energy technologies:

- $20 million to build a new class of sensor systems to enable significant energy savings via reduced demand for heating and cooling in residential and commercial buildings (SENSOR);
- $16 million to develop distributed, natural gas fueled devices that can generate electricity at greater than 70 percent efficiency (INTEGRATE);
- $24 million to create innovative technologies that enable designs for lower cost, safer, advanced nuclear reactors (MEITNER);
- $28 million for developing energy storage systems that provide power to the electric grid for durations of up to approximately 100 hours (DAYS).

ARPA-E released three additional funding opportunities in FY 2018 with project selections that were ultimately announced in FY 2019:

- $98 million for the agency's fourth open solicitation (OPEN 2018);

[1] The SENSOR and INTEGRATE FOAs were released in FY 2017, with project selections announced in FY 2018. The MEITNER and DAYS FOAs were released in FY 2018, with project selections also announced in FY 2018. Funding levels shown on pages iii-9 (inclusive) are as of each program's project selection announcement. The final number of projects and funding amounts are subject to change based on award negotiations and ongoing program management (see Table 2 of this report for updated data on each program).

- $29 million to develop new approaches and technologies for the design and manufacture of high temperature, high pressure, and highly compact heat exchangers (HITEMMP);
- $21 million to develop designs for medium voltage, direct current (MVDC) circuit breakers for a variety of applications (BREAKERS).

In addition to these new programs, ARPA-E hosted the ninth annual Energy Innovation Summit from March 13-15, 2018. The Summit brought together leaders from academia, government, and business to discuss the foremost energy issues, showcase the latest technology innovations, and cultivate relationships to help advance cutting-edge technologies towards deployment. The event drew nearly 1,800 attendees and featured over 100 speakers and keynote addresses.

ARPA-E announced that as of February 2018, 71 project teams have formed new companies, 109 projects have partnered with other government agencies for further development and an ever increasing number of technologies have already been incorporated into products that are being sold in the market. Additionally, 136 ARPA-E project teams have attracted more than $2.6 billion in private-sector follow-on funding.

In FY 2018, ARPA-E continued to focus on providing awardees with practical training and critical business information as part of the agency's Technology-to-Market program. This support equips projects with a clear understanding of market needs to guide technical development and help projects succeed in the marketplace.

ARPA-E ANNUAL REPORT FOR FISCAL YEAR 2018

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I. Legislative Language

This report is in response to the requirements set forth in the America COMPETES Act, Public Law 110-69, section 5012(g)(1)(2007) as amended, which has been codified as 42 U.S.C. § 16538(h)(1), wherein it is stated:

> *"...the Director shall provide to the relevant authorizing and appropriations committees of Congress a report describing projects supported by ARPA-E during the previous fiscal year."*

ARPA-E focuses on early-stage energy technologies that can be meaningfully advanced with modest funding over a defined period of time. ARPA-E's rigorous program design, competitive project selection process, and hands-on engagement provide America's energy researchers with funding, technical assistance, and market awareness. Each year, ARPA-E thoroughly reviews all applications and technologies to ensure that funding is provided to areas not currently undertaken by industry, Federal agencies, or other DOE applied research and development.

II. Fiscal Year 2018 Appropriation

The Consolidated Appropriations Act, 2018 (P.L. 115-141) included $353 million in FY 2018 funds for ARPA-E.

III. Funding Opportunity Announcements (FOAs)

In FY 2018, ARPA-E released five FOAs. Four FOAs were designed to advance innovative energy technologies in specific program areas and one was the agency's fourth open funding solicitation.

Project selections for two of these FOAs, as well as two FOAs released in FY 2017, were announced in FY 2018. Selections for three FY 2018 FOAs were announced in FY 2019. The technology programs created by these solicitations provide a unique bridge from basic science to early-stage technology. They draw from the latest scientific discoveries and will help create a viable path to commercial implementation through firm grounding in the economic realities and changing dynamics of the marketplace.

TABLE 1: Summary of ARPA-E FOAs Released and/or Awarded in FY 2018[2]						
Program	**FOA Issuance**	**FOA Issuance FY**	**Project Selection**	**Project Selection FY**	**Number of Projects**	**Funding Amount ($ Million)**[2]
SENSOR	1/18/2017	FY 2017	11/16/2017	FY 2018	15	$20M
INTEGRATE	7/26/2017	FY 2017	3/13/2018	FY 2018	8	$16M
MEITNER	10/20/2017	FY 2018	6/4/2018	FY 2018	10	$24M
OPEN 2018	12/13/2017	FY 2018	11/15/2018	FY 2019	40	$98M
DAYS	5/1/2018	FY 2018	9/18/2018	FY 2018	10	$28M
HITEMMP	8/9/2018	FY 2018	3/22/2019	FY 2019	15	$29M
BREAKERS	9/12/2018	FY 2018	2/5/2019	FY 2019	8	$21M
Total (Projects Selected)					106	$236M

Summary of FY 2018 Project Selections

In FY 2018, selections were announced for 43 projects across four technology programs:

On November 16, 2017, ARPA-E announced that 15 projects were selected to receive $20 million for **SENSOR** (*Saving Energy Nationwide in Structures with Occupancy Recognition*).

On March 13, 2018, ARPA-E announced that eight projects were selected to receive $16 million for **INTEGRATE** *(Innovative Natural-gas Technologies for Efficiency Gain in Reliable and Affordable Thermochemical Electricity-generation).*

On June 4, 2018, ARPA-E announced that ten projects were selected to receive $24 million for **MEITNER** *(Modeling-Enhanced Innovations Trailblazing Nuclear Energy Reinvigoration).*

On September 18, 2018, ARPA-E announced that ten projects were selected to receive $28 million for **DAYS** *(Duration Addition to electricitY Storage).*

Summary of FY 2019 Project Selections for FOAs Announced in FY 2018

In FY 2018 ARPA-E issued solicitations for three programs with project selections announced in FY 2019:

On November 15, 2018, ARPA-E announced that 40 projects were selected to receive $98 million for **OPEN 2018**. The FOA was issued on December 13, 2017.

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[2] Funding levels shown in this chart are as of each program's project selection announcement. The final number of projects and final funding amounts are subject to change based on award negotiations and ongoing program management (see Table 2 of this report for updated data on each program).

On February 5, 2019 ARPA-E announced that eight projects were selected to receive $21 million for **BREAKERS** *(Building Reliable Electronics to Achieve Kilovolt Effective Ratings Safely)*. The FOA was issued on September 12, 2018.

On March 22, 2019, ARPA-E announced that 15 projects were selected to receive $29 million for **HITEMMP** *(High Intensity Thermal Exchange through Materials and Manufacturing Processes)*. The FOA was issued on August 9, 2018.

Details on the FY 2018 Project Selections
The details of the focused programs with project selections announced during FY 2018 are:[3]

SENSOR: *Saving Energy Nationwide in Structures with Occupancy Recognition* ($20 million)
The projects that make up ARPA-E's SENSOR program will develop user-transparent sensor systems that accurately quantify human presence to dramatically reduce energy use in commercial and residential buildings. SENSOR projects will focus on one or more of four areas: 1) human occupancy sensors for residential use; 2) occupant-counting sensors for commercial buildings; 3) CO_2 sensors to enable the use of variable building ventilation based on data from occupant-counting sensors; and 4) real-world testing and energy savings validation of these technologies. Projects seek to reduce energy used by heating, ventilation, and air conditioning (HVAC) systems by 30 percent in both residential and commercial buildings, potentially producing savings of 2-4 quadrillion BTU (quads) across the U.S. power system. SENSOR projects will develop sensing technologies that minimize or eliminate the need for human intervention while pursuing aggressive cost, performance, privacy, and usability requirements in order to gain the acceptance and penetration levels needed to achieve this 30 percent reduction in HVAC energy consumption.

Example SENSOR Project: Purdue University – "Building-integrated Microscale Sensors for CO_2 Level Monitoring" – West Lafayette, IN ($1.5 million). The Purdue University team will develop a new class of small-scale sensing systems that uses an ensemble of resonant mass and electrochemical sensors to detect the presence of CO_2. The team will take advantage of low-cost circuit boards and off-the-shelf devices like commercial solar panels and batteries to reduce the cost of their system, enabling extremely easy to deploy, low-cost sensors.

[3] Project counts and funding amounts on pages iii-9 (inclusive) reflect information at the time of the project selection announcement. The final number of projects and final funding amounts are subject to change based on contract negotiations and ongoing program management (see Table 2 of this report for updated data on each program).

INTEGRATE: ***Innovative Natural-gas Technologies for Efficiency Gain in Reliable and Affordable Thermochemical Electricity-generation*** **($16 million)**
The projects that comprise ARPA-E's INTEGRATE program will develop natural gas fueled, distributed, ultra-high efficiency electrical generation systems. The program will focus on hybrid system designs that integrate a fuel cell with a heat or reactive engine, such as a gas turbine or a reciprocating internal combustion engine. The program encourages the development and demonstration of integrated hybrid systems and/or enabling component technologies. Project teams will seek to develop devices that can generate electricity at greater than 70 percent efficiency while keeping system costs competitive at commercial scales of 100kW or greater. Projects will take advantage of the synergies between fuel cells and more traditional combustion engines. For example, some of the fuel that passes through a fuel cell will remain "unreacted." This leftover fuel can be used by an engine to produce combustion products that produce additional power—improving overall system efficiency. Because the engine can be used simultaneously to generate power and act as balance-of-plant for the fuel cell, eliminating the need for some components, system cost savings could be significant.

Example INTEGRATE Project: Oak Ridge National Laboratory – "Development of Next-Generation Heat Exchangers for Hybrid Power Generation" – Oak Ridge, TN ($1 million). The Oak Ridge team will design and develop a high efficiency, high temperature, ceramic/steel alloy heat exchanger. The novel and low cost heat exchanger will be designed by optimizing the heat transfer surface with advanced modeling and will be fabricated using advanced 3D printing technology. If successful, this innovation would enable high performance, compact heat exchangers with unconventional and complex geometries that cannot be manufactured using conventional techniques.

MEITNER: ***Modeling-Enhanced Innovations Trailblazing Nuclear Energy Reinvigoration*** **($24 million)**
The projects that comprise ARPA-E's MEITNER program seek to identify and develop innovative technologies that can enable designs for lower cost, safer advanced nuclear reactors. These enabling technologies can establish the basis for a modern, domestic supply chain supporting nuclear technology. Projects will be improved and validated with advanced modeling and simulation tools, and project teams will have access to subject matter experts from nuclear and non-nuclear disciplines. An ARPA-E-provided Resource Team will coordinate sub-teams for modeling and simulation, techno-economic analysis, and subject matter expertise. Project teams will leverage these resources for modeling and simulation support, advanced technical information, design assistance, and information on the state of the art in relevant areas.

Example MEITNER Project: HolosGen, LLC. – "Transportable Modular Reactor by Balance of Plant Elimination" – Manassas Park, VA ($2.3 million). The HolosGen team seeks to develop a transportable, gas-cooled nuclear reactor with load following ability. By using a closed Brayton cycle engine with components connected directly to the reactor core, the team expects to simplify plant construction, leading to lower costs and shorter commissioning times. The

reactor can be packaged in a standard shipping container, making it highly portable and reducing cost. The team aims to demonstrate the viability of this concept using multi-physics modeling and simulation tools validated by testing a non-nuclear prototype.

DAYS: *Duration Addition to electricitY Storage* ($28 million)
The projects that comprise ARPA-E's DAYS program will develop energy storage systems that provide power to the electric grid for durations of 10 to approximately 100 hours, opening significant new opportunities to increase grid resilience and performance. Whereas most new energy storage systems today deliver power over limited durations, for example to alleviate transmission congestion, stabilize voltage and frequency levels, or provide intra-day shifts of energy, the extended discharge times of DAYS projects will enable a new set of applications including long-lasting backup power and even greater integration of domestic, renewable energy resources. Project teams will seek to develop storage systems that are deployable in almost any location and charge and discharge electricity at a target fixed cost per cycle. Projects will fall into two categories: 1) DAYS systems that provide daily cycling in addition to longer duration, less frequent cycling and 2) DAYS systems that do not provide daily cycling, but can take over when daily cycling resources are either filled or depleted. DAYS projects will explore a new design space in electricity storage that allows for strategic compromise of performance to achieve extremely low costs. The program also seeks to establish new paradigms for increasing stored energy and extending duration of stationary electricity storage systems.

Example DAYS Project: Echogen Power Systems (DE), Inc. – "Low-cost, Long-duration Electrical Energy Storage Using a CO_2-based Pumped Thermal Energy Storage System" – Akron, OH ($3 million). The Echogen Power Systems team will develop an energy storage system that uses a CO_2 heat pump cycle to convert electrical energy to thermal energy by heating a "reservoir" of low cost materials such as sand or concrete. The reservoir will retain heat that will be converted back into electricity on demand. To generate power, liquid CO_2 will be pumped through the high-temperature reservoir to a supercritical state, after which it will expand through a turbine to generate electricity from the stored heat.

Table 2 on the following page summarizes ARPA-E's programs to date. A full list of the projects selected during FY 2018 can be found in Appendix I. Additional information related to these projects is on ARPA-E's website: http://arpa-e.energy.gov.

TABLE 2: ARPA-E PROGRAMS TO DATE			
	PROGRAM NAME	**NUMBER OF PROJECTS**	**FUNDING AMOUNT ($ Million)[4]**
EXISTING PROGRAMS	OPEN 2009	41	$174
	Batteries for Electrical Energy Storage in Transportation (BEEST)	12	$38
	Innovative Materials and Processes for Advanced Carbon Capture Technologies (IMPACCT)	15	$40
	Electrofuels	13	$48
	Agile Delivery of Electrical Power Technology (ADEPT)	14	$38
	Building Energy Efficiency Through Innovative Thermodevices (BEETIT)	17	$38
	Grid-Scale Rampable Intermittent Dispatchable Storage (GRIDS)	15	$40
	Plants Engineered To Replace Oil (PETRO)	10	$56
	High Energy Advanced Thermal Storage (HEATS)	15	$37
	Rare Earth Alternatives in Critical Technologies (REACT)	14	$39
	Green Electricity Network Integration (GENI)	15	$43
	Solar Agile Delivery of Electrical Power Technology (Solar ADEPT)	7	$12
	Methane Opportunities for Vehicular Energy (MOVE)	13	$42
	Advanced Management and Protection of Energy Storage Devices (AMPED)	15	$34
	OPEN 2012	66	$171
	Innovative Development in Energy-related Applied Science (IDEAS)	59	$28
	Robust Affordable Next Generation Energy Storage Systems (RANGE)	22	$45
	Reducing Emissions using Methanotrophic Organisms for Transportation Energy (REMOTE)	16	$48
	Modern Electro/Thermochemical Advancements for Light metals Systems (METALS)	19	$45
	Full-Spectrum Optimized Conversion and Utilization of Sunlight (FOCUS)	14	$35

[4] Funding levels shown in this chart are as of February 2018 unless otherwise stated. DAYS, OPEN 2018, HITEMMP, and BREAKERS project counts and funding amounts reflect information at the time of selection. Final number of projects and funding amounts are subject to change based on award negotiations.

	Strategies for Wide Bandgap, Inexpensive Transistors for Controlling High Efficiency Systems (SWITCHES) & SBIR/STTR	14	$36
	Reliable Electricity Based on ELectrochemical Systems (REBELS)	13	$37
	Cycling Hardware to Analyze and Ready Grid-Scale Electricity Storage (CHARGES)	2	$6.5
	Delivering Efficient Local Thermal Amenities (DELTA)	11	$32
	Methane Observation Networks with Innovative Technology to Obtain Reductions (MONITOR)	12	$39
	Accelerating Low-cost Plasma Heating and Assembly (ALPHA)	9	$31
	Advanced Research In Dry cooling (ARID)	15	$33
	GENerators for Small Electrical and Thermal Systems (GENSETS)	14	$37
	Transportation Energy Resources from Renewable Agriculture (TERRA)	6	$38
	Traveler Response Architecture using Novel Signaling for Network Efficiency in Transportation (TRANSNET)	5	$15
	Micro-scale Optimized Solar-cell Arrays with Integrated Concentration (MOSAIC)	11	$26
	OPEN 2015	39	$124
	Network Optimized Distributed Energy Systems (NODES)	12	$35
	Generating Realistic Information for the Development of Distribution and Transmission Algorithms (GRID DATA)	7	$11
	Single-Pane Highly Insulating Efficient Lucid Design (SHIELD)	14	$27
	Integration and Optimization of Novel Ion-Conducting Solids (IONICS)	16	$37
	Next-Generation Energy Technologies for Connected and Automated On-Road Vehicles (NEXTCAR)	11	$35
	Rhizosphere Observations Optimizing Terrestrial Sequestration (ROOTS)	10	$36
	Renewable Energy to Fuels Through Utilization of Energy-Dense Liquids (REFUEL)	16	$33
	Energy-Efficient Light-Wave Integrated Technology Enabling Networks that Enhance Datacenters (ENLITENED)	9	$25
	Power Nitride Doping Innovation Offers Devices Enabling SWITCHES (PNDIODES)	7	$6.9
	Creating Innovative and Reliable Circuits Using Inventive Topologies and Semiconductors (CIRCUITS)	21	$30
	Macroalgae Research Inspiring Novel Energy Resources (MARINER)	18	$22

FY 2017 FOA / FY 2018 SECLECTION	Saving Energy Nationwide in Structures with Occupancy Recognition (SENSOR)	15	$20
	Innovative Natural-gas Technologies for Efficiency Gain in Reliable and Affordable Thermochemical Electricity-generation (INTEGRATE)	8	$16
FY 2018	Modeling-Enhanced Innovations Trailblazing Nuclear Energy Reinvigoration (MEITNER)	6	$14
	Duration Addition to electricitY Storage (DAYS)	10	$28
FY 2018 FOA / FY 2019 SELECTION	OPEN 2018	98	$40
	High Intensity Thermal Exchange through Materials and Manufacturing Processes (HITEMMP)	15	$29
	Building Reliable Electronics to Achieve Kilovolt Effective Ratings Safely (BREAKERS)	8	$21
	Total To Date	**864**	**$1,971**

IV. ARPA-E Energy Innovation Summit

The ninth annual ARPA-E Energy Innovation Summit took place March 13-15, 2018, at the Gaylord National Convention Center in National Harbor, Maryland. The Summit convened leaders from academia, business, and government to discuss the foremost energy issues, showcased cutting-edge energy technologies, and facilitated relationships to help move technologies towards deployment.

Throughout the three-day event, attendees also had the opportunity to explore the Technology Showcase, which featured ARPA-E awardees and a highly selective group of other companies, stakeholders, and research organizations. Many of the energy technologies displayed in the Technology Showcase were demonstrated publicly for the first time.

ARPA-E Energy Innovation Summit Highlights

- Nearly 1,800 registered attendees from 46 states and 12 countries
- Technology Showcase displaying nearly 300 breakthrough energy technologies from ARPA-E awardees and other innovative companies
- Panel discussions and networking sessions that enabled participants to meet with ARPA-E program directors, global industry leaders, and energy technologists
- Over 100 expert speakers and keynote addresses, including leaders from government, business, and academia
- Attendance and comments by a bipartisan group of U.S. senators and representatives

- Announcement that as of early 2018, ARPA-E had recognized several notable accomplishments, including:
    - At least 71 ARPA-E project teams have formed new companies to advance their technologies
    - 109 ARPA-E project teams have partnered with other government agencies for further development
    - 136 ARPA-E project teams have attracted more than $2.6 billion in private-sector follow-on funding.

V. Conclusion

In FY 2018, ARPA-E announced project selections for four focused programs. The programs created through these solicitations cover a wide range of technical areas:[5]

- SENSOR: development of a new class of sensor systems to enable significant energy savings via reduced demand for heating and cooling in residential and commercial buildings;
- INTEGRATE: development of distributed, natural gas fueled devices that can generate electricity at greater than 70 percent efficiency;
- MEITNER: development of innovative technologies that enable designs for lower cost, safer, advanced nuclear reactors;
- DAYS: development of energy storage systems that provide power to the electric grid for durations of up to approximately 100 hours.

At the 2018 ARPA-E Energy Innovation Summit, the Agency convened a diverse group of energy experts and industry leaders focused on advancing the next generation of breakthrough energy technologies. The Summit brought together leaders with unique perspectives, experiences, and ideas with the shared goal of revolutionizing the American approach to energy innovation.

The statutory goals of ARPA-E are to enhance the economic and energy security of the United States through the development of technologies that reduce imports of energy from foreign sources, reduce energy-related emissions, and improve energy efficiency across all sectors of the U.S. economy; and to maintain the United States' technological lead in the development and deployment of advanced energy technologies.

[5] The SENSOR and INTEGRATE FOAs were released in FY 2017, with project selections announced in FY 2018. The MEITNER and DAYS FOAs were released in FY 2018, with project selections also announced in FY 2018.

In FY 2018, ARPA-E program directors provided awardees with technical guidance and developed new programs by engaging diverse communities to identify gaps where ARPA-E funding could lead to transformational technologies enabling entirely new ways to generate, store, and use energy. The ARPA-E Technology-to-Market program provides practical training and business information to equip awardees with a clear understanding of market needs to guide technical development.

VI. Appendix I: Projects Selected in FY 2018

Additional information on these projects is available on the ARPA-E website: http://arpa-e.energy.gov.

PROGRAM	LEAD ORGANIZATION	PROJECT TITLE	LOCATION	ARPA-E FUNDING
MEITNER	General Atomics	Improved Load Following in an Advanced Nuclear Plant Using a High-efficiency Brayton Cycle with Variable-speed Generator	San Diego, CA	$1,455,762
MEITNER	General Atomics	Reducing Nuclear Plant Capital Costs Using Pre-cast Fiber-reinforced Concrete	San Diego, CA	$1,532,752
MEITNER	HolosGen, LLC	Transportable Modular Reactor by Balance of Plant Elimination	Manassas Park, VA	$2,278,200
MEITNER	North Carolina State University	Development of a Nearly Autonomous Management and Control System for Advanced Reactors	Raleigh, NC	$3,386,834
MEITNER	State University of New York at Buffalo	Reducing Overnight Capital Cost of Advanced Reactors Using Equipment-based Seismic Protective Technologies	Amherst, NY	$1,443,635
MEITNER	Terrestrial Energy USA, Inc.	Magnetically Suspended Canned Rotor Pumps for the Integral Molten Salt Reactor	New York, NY	$3,150,000
MEITNER	Ultra Safe Nuclear Corporation	Technology Enabling Zero-EPZ Micro Modular Reactors	Seattle, WA	$2,350,000
MEITNER	University of Illinois at Urbana-Champaign	Enabling Load Following Capability in the Transatomic Power MSR	Champaign, IL	$774,879
MEITNER	Westinghouse Electric Company, LLC	Self-regulating, Solid Core Block "SCB" for an Inherently Safe Heat Pipe Reactor	Cranberry Township, PA	$5,000,000
MEITNER	Yellowstone Energy	Reactivity Control Device for Advanced Reactors	Knoxville, TN	$2,599,185
SENSOR	Duke University	Detecting Human Presence Using Dynamic Metasurface Antennas (DMA)	Durham, NC	$404,878

SENSOR	Endeveo, Inc.	Hotspot Enabled Accurate Determination of Common Area Occupancy Using Network Tools (HEADCOUNT)	Boston, MA	$1,223,320
SENSOR	State University of New York at Stony Brook	SLEEPIR – Synchronized Low-energy Electronically-chopped PIR Sensor for Occupancy Detection	Stony Brook, NY	$1,000,000
SENSOR	Syracuse University	MicroCam: A Low Power and Privacy Preserving Multi-modal Sensor Platform for Occupancy Detection	Syracuse, NY	$1,200,000
SENSOR	United Technologies Research Center	PEOPLE: Platform to Estimate Occupancy and Presence for Low Energy Buildings	East Hartford, CT	$1,956,775
SENSOR	University of Colorado Boulder	Battery-free RFID Sensor Network with Spatiotemporal Pattern Network Based Data Fusion System for Human Presence Sensing	Boulder, CO	$2,000,000
SENSOR	Boston University	Scalable, Dual-Mode Occupancy Sensing for Commercial Venues	Boston, MA	$998,728
SENSOR	Cornell University	Indoor Occupant Counting Based on RF-backscattering	Ithaca, NY	$1,500,000
SENSOR	Rensselaer Polytechnic Institute	Reflected Light Field Sensing for Precision Occupancy and Location Detection	Troy, NY	$2,375,228
SENSOR	Scanalytics, Inc.	Floor Sensors for Occupancy Counting in Commercial Buildings	Milwaukee, WI	$851,957
SENSOR	Matrix Sensors, Inc.	Stable, Low Cost, Low Power, CO_2 Sensor for Demand-controlled Ventilation	San Diego, CA	$1,530,000
SENSOR	N5 Sensors, Inc.	Digital System-on-chip CO_2 Sensor	Rockville, MD	$1,530,000
SENSOR	Purdue University	Building-integrated Microscale Sensors for CO_2 Level Monitoring	West Lafayette, IN	$1,533,407
SENSOR	Iowa State University	Simulation, Challenge Testing & Validation of Occupancy Recognition & CO_2 Technologies	Ames, IA	$736,210

SENSOR	University of Alabama	Quantification of HVAC Energy Savings for Occupancy Sensing in Buildings Through an Innovative Testing Methodology	Tuscaloosa, AL	$1,496,655
INTEGRATE	Colorado School of Mines	High Efficiency, Low Cost & Robust Hybrid SOFC/IC Engine Power Generator	Golden, CO	$3,006,864
INTEGRATE	Oak Ridge National Laboratory	Development of Next-Generation Heat Exchangers for Hybrid Power Generation	Oak Ridge, TN	$1,000,000
INTEGRATE	Stony Brook University	Hybrid Electrochemistry-Advanced Combustion for High-Efficiency Distributed Power (HE-ACED)	Stony Brook, NY	$2,325,000
INTEGRATE	Saint-Gobain Ceramics and Plastics, Inc.	Super High-efficiency Integrated Fuel-cell and Turbo-machinery (SHIFT)	Northboro, MA	$2,801,430
INTEGRATE	FuelCell Energy, Inc.	Adaptive SOFC for Ultra High Efficiency Power Systems	Danbury, CT	$3,099,613
INTEGRATE	Nexceris, LLC	Advanced Solid Oxide Fuel Cell Stack for Hybrid Power Systems	Lewis Center, OH	$2,150,356
INTEGRATE	Washington State University	De-Coupled Solid Oxide Fuel Cell Gas Turbine Hybrid (dFC-GT)	Pullman, WA	$678,014
INTEGRATE	University of Wisconsin - Madison	Integrated High Pressure SOFC and Premixed Compression Ignition Engine System	Madison, WI	$1,012,000
DAYS	National Renewable Energy Laboratory	Economic Long-duration Electricity Storage by Using Low-cost Thermal Energy Storage and High-efficiency Power Cycle	Golden, CO	$2,791,595
DAYS	Michigan State University	Scalable Thermochemical Option for Renewable Energy Storage (STORES)	East Lansing, MI	$2,000,000
DAYS	Brayton Energy, LLC	Improved Laughlin-Brayton Cycle Energy Storage	Hampton, NH	$1,994,005
DAYS	Form Energy, Inc.	Aqueous Sulfur Systems for Long-duration Grid Storage	Somerville, MA	$3,948,667
DAYS	Quidnet Energy, Inc.	Geomechanical Pumped Storage	San Francisco, CA	$3,298,786
DAYS	Primus Power	Minimal Overhead Storage Technology for Duration Addition to Electricity Storage	Hayward, CA	$3,500,000

DAYS	University of Tennessee, Knoxville	Reversible Fuel Cells for Long-duration Storage	Knoxville, TN	$1,500,000
DAYS	Echogen Power Systems (DE), Inc.	Low-cost, Long-duration Electrical Energy Storage Using a CO2-based Pumped Thermal Energy Storage System	Akron, OH	$3,000,000
DAYS	United Technologies Research Center	High-performance Flow Battery with Inexpensive Inorganic Reactants	East Hartford, CT	$3,000,000
DAYS	Antora Energy	Solid State Thermal Battery	Fremont, CA	$3,000,000